sulphur-yellow round the branchial orifice, continuous with a stripe or blotch of the same colour above; they are arranged in short, ill-defined, branching systems, with the common orifices indistinct. Diameter of mass two to two and a half inches.

I met with this species on the under side of stones within tide-marks, St. Peter's Port, Guernsey, in 1853. This and the following species have the individuals more minute than is usual in the genus.

Botrylloides pusilla, n. sp.

Common body encrusting, semitransparent, orange-flesh-coloured, with yellow marginal tubes. *Individuals* small, bright orange-scarlet, consisting of a minute sprinkling of scarlet on a yellow ground; there is a yellow spot behind the branchial aperture, and the anal aperture is also yellow; the individuals are set in crowded double or treble rows, forming ill-defined systems. *Branchial sac* with ten rows of stigmata. Diameter of mass nearly two inches. Length of individuals half a line.

A single specimen of this beautiful and very distinct *Botrylloides* was got on the under side of a stone at Grand Havre, Guernsey, in 1853.

Figures of most of the species here described, along with others not previously or hitherto imperfectly figured, will be given in an illustrated Catalogue of British Tunicata, now preparing for the British Museum.

EXPLANATION OF PLATE VII.

Fig. 1. A portion of the branchial sac of *Ascidia parallelogramma*, highly magnified.
Fig. 2. Two spiral coils of the same, more highly magnified.
Fig. 3. A small portion of the branchial sac of *Molgula arenosa*, showing the cones in profile.
Fig. 4. Two of the cones seen in front.

XIX.—*On the Composition of the Head, and on the Number of Abdominal Segments, in Insects.* By Dr. H. Schaum.

[Plate VI.]

As the opinion has lately gained much ground among the comparative anatomists of England, chiefly through the embryological researches of Prof. Huxley, that the head of the Arthropoda is made up of a number of segments, I desire to draw attention to some facts which seem to militate against this view. Prof. Huxley* admits, with regard to the greatest number of

* "On the Agamic Reproduction and Morphology of *Aphis*," Trans. Linn. Soc. xxii. p. 229 &c.

appendages attached to the head in any case (in Crustacea), six segments composing the head of Arthropoda,—the first bearing the eyes, the second and third the two pair of antennæ, and the fourth, fifth, and sixth the three pairs of maxillæ (the third of which is soldered to the lower lip in insects). For *insects*, he reduces the number to five, as they have never more than one pair of antennæ.

In seeking for some arguments against this conclusion, I may be allowed to start, *not* from the head provided with the greatest number of appendages, but from the head of *insects*,—first, because the statement that a pair of appendages is the exponent of a separate segment may be considered as a *petitio principii* by one who desires to disprove it; and secondly, because it is only in insects that the head is a section of the body into which nothing but the head itself enters. In Crustacea, either a part of the thorax (as in Isopoda) or the whole thorax (as in Decapoda) is intimately united with the head into one portion; and in Arachnida there is no proper head at all.

In the head of insects we have five pairs of appendages, if we admit, from the analogy of the moveable eyes in the Podophthalmous Crustacea, that the sessile eyes are appendages comparable to the antennæ and maxillæ. As it is proved, by the second and third thoracic segments bearing wings and legs at the same time, that the same segment may be provided with a pair of both tergal and ventral appendages, we might at first conclude that the eyes and antennæ are the tergal appendages of the same segments which bear maxillæ as their sternal ones. The number of the segments of the head would thus be reduced to three, which is, indeed, a conclusion admitted by some entomologists*. But Prof. Huxley has been led, by his observations on the development of *Aphis*, to the conclusion that both eyes and antennæ are also sternal, and not tergal appendages. With regard to these observations, I cannot refrain from mentioning that scarcely any object could be chosen which offers a greater difficulty to the observer for seizing clearly this fact than *Aphis*; for the *Aphides* not only leave the egg in a comparatively perfect state, undergoing afterwards scarcely any metamorphosis, but they have also the front and even the vertex bent downwards, so as to be visible on the underside of the head. How is it to be decided, in such an embryo, which is the sternal and which the tergal part of the two segments, which, according

* The *labrum* is considered by some entomologists, as by Brullé (Ann. des Sc. Nat. 1844, p. 345), as representing also a pair of soldered maxillæ lying above the mandibles: this analogy is, however, completely rejected by Prof. Huxley, on the ground that the labrum is developed in the medial line of the body (*l. c.* p. 232. 9).

to Prof. Huxley, are situated *before the mouth*? We get no information from the author, as the terga of these segments are not traced by him.

But leaving the point whether the eyes and antennæ are tergal or sternal appendages in *Aphis*, sufficient proof can be given that it is inaccurate to state that a pair of appendages is always dependent upon a separate segment. It is a general law, that insects leave the egg with the full number of their segments, and that no segment is ever added during the metamorphosis, though some of the abdominal ones may disappear externally in the perfect state. A great number of larvæ, however, leave the egg completely blind, and even destitute of antennæ, with a head on which no trace whatever of a division into subsegments can be discovered. How, in this case, can the subsequently developed eyes (which are here certainly tergal, and not sternal appendages) be considered as appendages of a proper segment which has never existed? And how are the ocelli to be accounted for, which, like the wings, make their appearance first in the perfect state, but which cannot, like the wings, be referred to a proper pre-existing segment?

The abdominal segments of *Julidæ*, provided with a double pair of legs, furnish us with another proof that the same segment may bear more than one pair even of ventral appendages. To dispose of this proof it is usually asserted that there are two segments united into one; but not a single observation on the production of these segments during the growth of the animal has been made which supports that theory. On the contrary, I conclude, from Newport's observations and figures, that the new segments which are added to the abdomen appear always from the first with two pairs of legs, and never show a division into two.

If, therefore, the number of appendages is not a just test of the number of segments entering into a part, we have to inquire what are the requisites of a segment, when we undertake to settle the question whether the head is made up of one or of several segments. It will meet with no opposition when, in the first instance, we require that a segment must be marked by a transverse line of demarcation on the integument of the animal, at least in an early stage of its development. Another requisite of a segment is, that it must constitute a ring composed of a dorsal and a ventral arcus. A segment requires, further, normally, a set of proper muscles and a ganglion. A ganglion need not be traced in each segment of the perfect insect, where a number of segments are united to a greater section of the body (thorax or abdomen); but in the *larvæ*, with homonomous segments, the nervous system forms regularly a chain of ganglia corresponding

to the segments. We find no trace of subsegments on the integument of the head in any stage of the development; we find no sets of different muscles, and never more than one *ganglion infraœsophageum* in the head. Are we not therefore entitled to draw from these facts the conclusion that the head of insects constitutes but a single segment, especially since we may trace in many Coleoptera a dorsal and a ventral arcus of it, united in two deep lines corresponding to sutures on the jugulum? It is certainly a segment more complicated than the others; but should we not expect this, since it contains the *ganglion supraœsophageum*, the principal organs of the senses, and the mouth*? Applying the same views to the Crustacea, we are not entitled to admit there, any more than in the Insecta, different segments of the head for the different appendages,—not even in *Squilla*, where the eyes and interior antennæ are inserted, it is true, on a separate plate, though a plate which is not analogous to a true segment †.

Keeping in view the requisites of a segment, we may also arrive at a positive and satisfactory result as to the normal number of segments composing the abdomen of insects, which has also been a subject of discussion in the memoir of Prof. Huxley on the development of *Aphis*. This result is, that in no case does the number of abdominal segments exceed *nine*. In insects which undergo a complete metamorphosis, this is satisfactorily proved by the fact that no larva has more than thirteen segments ‡,—the first being the head, the three following constituting the thorax, and the last nine the abdomen. Newport (Todd's Cyclopædia) and Westwood (Introd. to the Modern Classif. of Insects, i. p. 194, and ii. p. 240) speak, indeed, of a fourteenth segment of the body in the larvæ of aculeate Hymenoptera and of the Scarabæidæ, in like manner as some lepidopterologists speak of a fourteenth (anal) segment of caterpillars; but it has long ago been proved by Erichson and Stein § that this supposed tenth segment of the abdomen is nothing but the externally protruded anus, analogous to the anal proleg of the larvæ of many Coleoptera (which no one ever thought of considering a segment). As the number of segments does not increase after the larva has escaped from the egg, we cannot have more than nine segments in any insect undergoing a

* I may also mention that those who admit several segments have never undertaken to state the position which the *ganglion supraœsophageum* occupies with regard to these segments.

† Erichson, Entomographien. Berlin, 1840, p. 17.

‡ Some larvæ, as those of *Dytiscidæ* and *Hydrophilidæ*, have, however, but twelve (eight being abdominal).

§ Vergleichende Anatomie der Insecten, i. p. 23, not. 4.

complete metamorphosis. These nine segments are, however, but seldom conspicuous in the perfect insects of this division, and only their dorsal half-segments: the number of ventral half-segments is always less than that of the dorsal ones, although both half-segments are equally developed in the *larva*. Of the dorsal half-segments, the last, or even the last two, often disappear at the apex of the abdomen, being retracted within its cavity during the pupa state; of the ventral half-segments, not only the last or the last two are retracted at the apex during the transformation to the perfect state, but also the first, and often the first and second, disappear externally at the base of the abdomen, being usually pushed inwards so as to form a kind of *phragma* between the thorax and abdomen. The first conspicuous ventral arcus in the perfect insect is, therefore, not the one corresponding to the first, but the ventral arcus corresponding to the second or third dorsal arcus*. In this way it is to be explained how the number of visible ventral half-segments in perfect insects is often reduced to five, six, or seven, while the number of the dorsal ones amounts to seven, eight, or nine.

In counting the latter, we have always to begin with the one which bears the pair of large spiracles, so characteristic already, for the first abdominal segment, in the larva, however intimate the union of that half-segment with the metathorax may be. It is, for instance, so intimate in the Staphylinidæ, that even Erichson, neglecting the stigmata, considered it for some time as a part of their metathorax†. It is still more intimate in the Hymenoptera aculeata, where the first segment is severed from the rest of the abdomen by a more or less deep incision, and is immoveably applied to the metathorax—constituting that part which is called by MacLeay, Newport, and Westwood the postscutellum of the metathorax‡.

* Erichson, Archiv, 1848, ii. p. 61.

† Erichson, Archiv, 1845, ii. pp. 80, 81; Stein, Vergleichende Anatomie d. Ins. p. 11.

‡ That the so-called postscutellum of the metathorax in Hymenoptera aculeata is in reality the first dorsal abdominal segment, as contended by Audouin and Latreille, is not only proved by the size and position of its stigmata, corresponding to those of the first abdominal segment of the larva (while the metathorax has nowhere any stigmata), but also by the changes which take place in the segments during the pupa state. It is the *sixth* segment of the larva (second abdominal) which forms the petiolus, by which *what seems to be the whole abdomen* is attached to the thoracic portion, the *fifth* (first abdominal) applying itself intimately during these changes to the metathorax (Cf. the figures of Ratzeburg, copied by Westwood, Introd. ii. fig. 86. 4 & 5). The three parts of the body, so conspicuous in the Wasp, do not, therefore, as generally believed, exactly correspond to the head, thorax, and abdomen; but the first to the head, the second to the thorax + first abdominal segment, the third to the abdomen — the first segment.

When we determine the number of abdominal segments in those insects undergoing an incomplete metamorphosis*, we cannot start from the simpler organization of the larva; but we have here, as in the other section, a safe guide in the *stigmata*. With the exception of the last, all the dorsal half-segments of the abdomen are provided with a pair of spiracles in the soft membrane which connects them with the ventral half-segments; and the first is usually remarkable from its large size and its position on the back of the abdomen. Beginning with the arcus bearing those stigmata, we count on the back of the abdomen, in both sexes of *Locusta*, ten parts, which at first sight appear to be segments; but, on a closer examination, we are led to the conclusion that the tenth part (called *lamina supraanalis* by orthopterologists) is not to be considered as a segment. The first eight dorsal half-segments are easily identified by their stigmata (Pl. VI. fig. I. 1–8); the ninth has no stigmata, and is differently shaped in both sexes (figs. I. & II. 9), but is still united by a connective membrane to the last ventral half-segment, while the tenth (figs. I. & II. *c*), provided on its under side with a pair of *styli* (*d*), and also differently shaped in both sexes, is not connected by a membrane to the ventral segments. The number of the latter amounts to eight in the male, and to seven in the female†, the last being differently shaped in both sexes, and bearing in the male another pair of styli (fig. I.*e*). With the last of these (eighth in the male, seventh in the female), called *lamina subgenitalis* by orthopterologists, the ninth dorsal half-segment forms the apex of the abdomen and an involucrum both for the anus and the sexual organs, the dorsal arcus (9) being the bearer of the anus, and the ventral arcus (8 or 7) that of the sexual organs (figs. I. & II.,—the position of the rectum in the abdomen

* With regard to the movements which some Neuroptera undergoing a complete metamorphosis perform as pupæ, it has lately been denied by some entomologists that a distinct limit could be traced between a complete and incomplete metamorphosis when they approach the end of this period: in denying this, however, they lose sight of a fundamental difference in the organization of the pupa, which does not even admit the possibility of a passage. In the true pupa, the skin shuts both the mouth and anus, so that no food can be taken and no fæces be discharged; whilst in the pseudo-pupa of the hemimetabolous insects the mouth and anus are open, as in the larva and in the perfect insect.

† The posterior part of the metasternum (Pl. VI. fig. I. M, coloured blue), expanded between the posterior coxæ, might easily be taken for the first ventral segment, as it is separated from the anterior part of the metasternum by a deeply impressed line, by which the number of ventral segments would be raised to nine in the male and to eight in the female. That it is, however, in reality a part of the metasternum can be ascertained when we compare it with the corresponding part in *Pachytylus* (fig. III.) and *Forficula* (fig. V.), where there can be no doubt as to its nature.

being indicated in fig. II. by a double series of red, that of the vagina by a double series of blue points). The *ninth* dorsal segment is thus proved to be the last of the whole body; the tenth part (*c*) is nothing but a plate which covers the anus, as the upper lip covers the mouth, and can as little as the latter, or the anal proleg of a larva, be considered as a segment.

In *Pachytylus migratorius*, also, we count nine dorsal segments in both sexes, eight ventral segments in the male (fig. III.), and seven in the female (fig. IV.). The ninth dorsal segment is, in both sexes, apparently divided by a transverse impressed line into two; nevertheless in reality it is simple (figs. III. B 9 & IV. A 9); the *lamina supraanalis* (*c*) and the styli (*d*) are analogous to the same parts in *Locusta*. In the male, the last ventral segment has also on each side a transverse impressed line (fig. III. B 8), which might, as in the last dorsal segment, be considered (but erroneously) as indicating the demarcation of two segments; the last (seventh) ventral segment of the female (fig. IV. B) is without any trace of such a line. The ninth dorsal and the last ventral half-segment, forming the apex of the abdomen (figs. III. B & IV. A), involve, as in *Locusta*, the upper (9) the anus, shut by the *lamina supraanalis* (*c*), the lower (fig. III. B 8, fig. IV. A 7) the sexual organs, which open in the female (fig. IV. A) between the four parts constituting the ovipositor (fig. IV. A *o*) (as in *Locusta*, between the four laminæ of the sword, fig. II. *o*), and which are separated in this case from the anus by a transverse septum (fig. IV. A *d*, where the position of the rectum is, as in *Locusta*, indicated by a double series of red, and the position of the vagina by a double series of blue points*).

* M. Lacaze Duthiers states, in his memoir on the female genital apparatus of insects (Ann. des Sc. Nat. 1833, vol. xix.), that in Neuroptera, Orthoptera, and Hemiptera, three segments (somites) intervene between the *vulva*, which is said to open between the eighth and ninth abdominal segments and the anus, said to be situated on the eleventh segment. I have not been able to confirm these statements. In Hemiptera, in accordance with the observations of Fieber (the best monographer of this order), I never find more than eight dorsal segments. In the Neuroptera with complete metamorphosis, there cannot be more than nine segments, as the larvæ have but nine. In Orthoptera, where the anus and vulva open between the last dorsal and last ventral arcus, forming an involucrum (the ninth dorsal and the seventh ventral where that number is greatest), I see nowhere even the possibility of counting eleven segments, except in *Acridia* (*Pachytylus*), if there the ninth dorsal segment be counted as double and the *lamina supraanalis* as a segment, while the transverse septum (Pl. VI. fig. IV. *d*) is considered as a ventral half-segment. As to the view of M. Lacaze Duthiers, that the various female genital organs, such as sting, borer, ovipositor, &c. (the analogous composition of which in Hymenoptera had already been proved by Prof. Westwood), are the result of modifications of the ninth abdominal segment, I doubt much whether observations on the changes of that segment during the pupa state will confirm this

In the male of *Forficula gigantea*, and allied species, there are also nine dorsal segments (Pl. VI. fig. v. 1–9), a *lamina supraanalis* (*c*), which attains here a great size, a pair of forceps analogous to the style (*d*), and eight ventral segments; while in the female there are but seven dorsal and six ventral segments conspicuous externally. The *lamina supraanalis* has in this case been counted by Prof. Westwood, in a paper on the external anatomy of *Forficula* (Trans. Ent. Soc. i. p. 157, pl. 16. fig. 6), as the ninth dorsal segment of the male, because he erroneously considered the first abdominal segment (fig. v. 1 & fig. vi. 1) as a part of the metathorax (m), believing that it might thus be proved that in *Forficula* at least the metathorax is provided with a pair of spiracles (which is, however, nowhere the case). There can be no doubt as to the nature of the part in the apterous genus *Chelidura* corresponding to this in the *Forficulæ*. It fills there the posterior sinus of the metathorax, being quite separated from the latter, and covered at its sides by the produced angles of it, beneath which the stigmata of the first segment are concealed.

In all these insects, as in all those undergoing a complete metamorphosis, the number of ventral half-segments is less than that of the dorsal ones, being eight in the male and seven in the female of both *Locusta* and *Pachytylus*, and being also eight in the male of *Forficula**; and it is, as in the holometabolous insects, the first dorsal arcus which has no corresponding ventral arcus.

There remains, however, one group of insects in which, according to the general opinion, ten segments of the abdomen, both the dorsal and ventral half-segments, are fully developed,

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view, which, however, could only be proved in that way. Observations on the pupæ of Coleoptera led Erichson to the conclusion that the horny parts of the genital organs are not modifications of the last segments, but are developed independently of them (Erichson, Archiv, 1848, ii. p. 62). In trying to prove his thesis by the composition of those organs in perfect insects, M. Lacaze Duthiers starts from a theoretical axiom, that each segment of insects is normally composed of six parts—three tergal ones (one tergum and two epimera) and three sternal ones (one sternum and two episterna),—and that it bears a pair of tergal and sternal appendages, called by him "tergorhabdites" and "sternorhabdites." He then refers the parts composing the genital organs to the tergum or epimera, or sternum or episterna, or tergorhabdites or sternorhabdites of the ninth abdominal segment. It is, however, only in the wing-bearing segments that six parts can be really distinguished, and that tergal appendages exist; and here the epimera are sternal, and not tergal parts, like the pieces designated by M. Lacaze Duthiers the epimera of the ninth segment.

* By a mistake which I cannot explain, Prof. Westwood, in his paper on *Forficula* (*l. c.* pl. 16. fig. 6), figures the metasternum (Pl. VI. fig. v. m), to which the posterior legs are attached, as the first ventral segment of the abdomen, and thus enumerates *nine* ventral segments.

and in which the tenth bears the anal appendages—namely, the *Libellulæ*. In these insects what is generally counted as the first abdominal segment is, however, a posterior part of the metathorax—separated, it is true, by a deep incision and a softer membrane capable of some extension*, but not by a complete articulation, from the anterior portion of it. There are two reasons which seem to settle this point beyond doubt. In the first place, this apparent segment is destitute of spiracles, the first of the seven conspicuous pairs of spiracles lying in the connective membrane of the dorsal and ventral arcus of the apparently *second* segment†. A first abdominal segment destitute of spiracles is without any analogy in the Insecta, while, on the contrary, it is a characteristic feature of the metathorax that it never has spiracles. A second argument in favour of this opinion is, that the apparently first segment is developed, during the metamorphosis of *Libellula*, in proportion to the growth of the wings. In the young larva we count only nine abdominal segments, of which the ninth bears the anal plates; in a larva of moderate size which has already undergone some moultings, and where the future wings appear on the back of the thoracic segments, that part begins to show itself; even in the pseudopupa, previous to its last transformation, it is still but little developed; and it is only in the perfect insect that it completely assumes the shape of an abdominal segment. The metathorax there attains an unusual development, but a development quite in proportion to the posterior wings, which are, in the *Libellulæ*, of even a larger size than the anterior ones, and which are moved during flight by a system of proper muscles; while in other orders, as, for instance, in Hymenoptera, they are moved by the same system of muscles as the anterior ones, being connected to them, during flight, by the hooks of their anterior margin.

According to this view, the penis of the *Libellulæ* is situated, not on the second, as usually stated, but on the first ventral segment; and the outlets of the generative organs are, in both sexes, on the eighth, and not on the ninth, ventral segment—those of the male in the middle, those of the female at the base of it. In this group the posterior part of the eighth and the whole ninth ventral segment intervene between the vulva and the anus, the latter occupying, as usual, the end of the ninth segment, which bears the anal appendages; and in this group, also, the nine ventral half-segments are all developed.

Having thus ascertained that in insects the abdomen is as

* A similar soft membrane exists between the anterior and posterior portions of the mesothorax (scutellum and postscutellum) in the Hymenopterous genus *Eupelmus*.

† Hagen, Stett. Entom. Zeit. 1853, p. 319.

well defined as is the thorax by the number of segments which compose it, we may certainly take the three divisions of the body, as they are constituted in insects, as the standard to which the segments of the higher Crustacea are to be referred, if we desire to settle what are their cephalic, thoracic, and abdominal segments. We will not state, then, that the thorax of Arthropoda is normally composed of seven segments. In Isopoda and Amphipoda, where the part usually called the thorax is divided into seven leg-bearing segments, the segment corresponding to the prothorax of insects has completely disappeared, its legs being added to the head in the shape of a lower lip with palpi; the first and second of the seven leg-bearing segments are analogous to the meso- and metathorax, and the five others, as well as the segments of the so-called abdomen, to abdominal segments,—the abdomen being here, as in all higher Crustacea, composed of a greater number of segments than in insects, and divided into an anterior (pectoral) and posterior (caudal) portion*. To the five segments constituting the pectoral part of the abdomen in Isopoda the five leg-bearing segments of Decapoda are analogous, whose thoracic segments are all united to the head (their legs constituting the three pair of accessory masticatory organs) and whose pectoral portion also enters into the part usually called the cephalothorax†.

EXPLANATION OF PLATE VI.

Fig. I. *Locusta viridissima*, ♂, seen sideways.
Fig. II. The same, ♀; apex of abdomen.
Fig. III. A. *Pachytylus migratorius*, ♂, seen from beneath.
Fig. III. B. Terminal segments of the male of *Pachytylus migratorius*, seen sideways.
Fig. IV. A. *Pachytylus migratorius*, ♀; last abdominal segments, seen sideways.
Fig. IV. B. The same, seen from beneath.
Fig. V. *Forficula gigantea*, ♂; abdomen seen sideways.
Fig. VI. *Forficula gigantea*; metathorax (M) and first two abdominal segments.

XX.—*Note on the Colouring Matter of the Red Sea.*

By H. J. Carter, F.R.S. &c.

To those who have sought for all that has been published on the colouring matter of the Red Sea, it will be well known that the excellent memoirs on this subject by M. C. Montagne in 1844, and M. C. Dareste in 1855 (both in the 'Ann. des Sc. Nat.,' the former in sér. 3 (Bot.) t. ii. p. 331, and the latter in

* Erichson, Entomographien, pp. 14–16.
† Brandt, Medic. Zoolog. ii. p. 58; Erichson, *l. c.* p. 19.